Mukhtarov, S., Aliyev, J., Borowski, P.F., & Disli, M. (2023). Institutional quality and renewable energy transition: Empirical evidence from Poland. *Journal of International Studies, 16*(3), 208-218. doi:10.14254/2071-8330.2023/16-3/12

Journal
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Scientific Papers

Institutional quality and renewable energy transition: Empirical evidence from Poland

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Abstract. This study investigates the impact of institutional quality as measured by the corruption perception index, income, CO_2 emissions, and trade openness on renewable energy consumption in Poland from 1996 to 2021. The Canonical Cointegrating Regression (CCR) technique was employed for empirical analysis. The analysis results revealed that the corruption perception index, income, and CO_2 emissions have a positive and statistically significant effect on renewable energy consumption, while trade openness has an insignificant impact. The positive influence of institutional quality on renewable energy consumption

Received: September, 2022
1st Revision: May, 2023
Accepted: September, 2023

DOI: 10.14254/2071-8330.2023/16-3/12

highlights the significance of implementing policies that contribute to environmental sustainability and energy security.

Keywords: institutional quality, renewable energy, CCR, corruption, Poland.

JEL Classification: Q01, Q20, Q28, Q42

1. INTRODUCTION

Environmental degradation has recently become a major global issue, while the search for solutions that could minimize the detrimental effects of environmental problems has grown increasingly challenging. Acheampong et al. (2021) state that 1% of world GDP must be sacrificed to address climate change costs. However, such a sacrifice might significantly weaken the global economy and impede its future growth (Hadj et al., 2023; Mukhtarov et al., 2022a).

The rising emission of greenhouse gases is one of the most crucial challenges in the context of environmental issues since it is the main culprit behind global warming and environmental damage. To address this problem, shifting toward cleaner and more sustainable energy is vital. Numerous studies emphasize that achieving a significant reduction in greenhouse gas emissions would be extremely difficult without a substantial increase in the adoption of renewable energy sources (Lie et al., 2023; Troster et al., 2018; Mohsin et al., 2021). Considering this, many international institutions, such as the International Energy Agency (IEA), the Organization of Economic Cooperation and Development (OECD), and the United Nations (UN), have resolved to substitute non-renewable energy sources with renewable ones to avoid harmful gas emissions. For example, the UNDP's Sustainable Development Goal (SDG) 7 pertains to clean and affordable energy. However, international institutions have limited influence on the transition to renewable energy because certain factors, such as economic growth and the country's institutional quality, play undeniably more significant roles in this process (Chen et al., 2021).

Institutional quality is a comprehensive concept that refers to the characteristics and attributes of institutions such as governments, government agencies, legal systems, political systems, and public administration. Collectively, these elements create the overall environment and climate in which businesses and organizations operate (Chowdhury et al., 2019). Institutional quality can be considered from several viewpoints that determine effectiveness, efficiency, transparency, and legitimacy (Gasimov et al., 2023b). The concept of effectiveness involves evaluating whether institutions successfully reach their predetermined objectives and if the results are achieved with efficiency and proficiency (Poniatowicz et al., 2020). On the other hand, efficiency indicates the effective utilization of available resources (such as human resources and finances) to achieve maximum benefits at minimal costs (Kakwezi and Nyeko, 2019). An essential aspect of institutional quality relates to transparency, encompassing transparency, accountability, and consequences for actions and providing information on finances and decision-making. This aspect is also linked to the rule of law, indicating the extent to which the legal system is transparent, predictable, and impartial (Ruijer et al., 2020). Analyzing the legal system also involves examining the stability of the political system and the protection of property rights, covering the important area of public distributive policy (Mishchuk et al., 2019). When discussing issues related to renewable energy sources, attention should be given to regulations and their impact on the economy. This includes examining competitiveness, efficiency, and the protection of consumers' and investors' interests (Gasimov et al., 2023b).

The quality of institutions, including government policies, regulations, and management structures, significantly impacts the renewable energy sector in several ways: firstly, by formulating and implementing policies related to renewable energy (Du et al., 2022; Hille et al., 2020). Clear and supportive policies, such as guaranteed tariffs, tax incentives, and renewable energy targets, can encourage investment and promote the development of renewable energy technologies. Transparent and stable regulatory frameworks can provide long-term certainty for renewable energy projects (Lu et al., 2020; Štreimikienė, 2021). Investments play a crucial role in renewable energy development; thus, institutional quality influences the attractiveness of investments in renewable energy. Well-functioning institutions can reduce investment risks, protect property rights, and create a favourable business environment. Strong institutional frameworks can attract both domestic and foreign investments, including venture capital and private equity.

Government institutions are characterized by ease in effectively implementing various policies, including energy policy if they have strong constitutional and political power and social legitimacy (Adams et al., 2019; Krzymowski, 2020). Successfully implemented energy policies by the government to enhance energy efficiency can subsequently determine citizens' attitudes toward energy consumption and the implementation of energy-saving policies (Bertoldi, 2022; Jin et al., 2022). However, this depends on how effectively these institutions enforce such policies and how strong the state institutions are (Yan et al., 2021). Much research has focused on the consequences of government energy policy, with earlier studies concentrating on the effects of government policies on reducing energy consumption in energy-intensive sectors and energy efficiency (Safarzadeh et al., 2020) or energy security policy (Jakstas, 2020; Sachs et al., 2019). Currently, there is a huge interest in studies conducted on the efficiency of government institutions, considering the impact of institutional quality on energy efficiency (Uzar, 2020b; Wang et al., 2023). However, to the best of our knowledge, there is a limited amount of research in this area that includes institutional quality while analyzing the factors affecting the transition to renewable energy. In this regard, we aim to evaluate and contribute to the literature by assessing the impact of institutional quality proxied by the corruption perception index on renewable energy consumption, employing time series analysis in the case of Poland. It is worth noting that our study is unique in that no time-series study investigated the institutional quality and renewable energy relationship in the case of Poland.

2. LITERATURE REVIEW

Considering the importance of the transition to renewable energy, several studies were conducted to examine the factors affecting clean and more affordable energy (SDG 7). However, institutional quality indicators were not considered in most of the studies, as the focus was given to CO2 emissions, oil prices, economic growth, and other drivers of renewable energy consumption (REN) (Bhattacharya et al., 2017). In the provided table, we have summarized some of the few research studies that explore the connection between renewable energy and the quality of institutions. By analyzing the information in the table, we can draw the conclusion that nearly all of these studies show that the quality of institutions has a noticeable effect on renewable energy. This highlights the fact that the strength of institutions plays a crucial role in driving the development of renewable energy sources.

Considering the existing literature, it can be deduced that a few studies have considered the effects of institutional quality on renewable energy while also considering other important variables. Given that institutions play a critical role in shaping energy and environmental policies, as well as monitoring investments toward clean energy, it becomes significantly important to include them while analyzing the economic indicators that affect the transition to renewable energy. In this regard, our study makes a valuable contribution to the existing literature by including the variable of institutional quality alongside other crucial factors, such as CO2 emissions, trade openness, and economic growth.

Table 1

A Summary of Literature on Renewable Energy and Institutional Quality Nexus

Study	Country	Time	Type of Analysis	REN effect of institutional quality
Cadoret and Padovano (2016)	26 EU countries	2004-2011	Panel	P&S
Uzar (2020a)	38 selected countries	1990-2015	Panel	P&S
Uzar (2020b)	43 developed and developing countries (including Poland)	2000-2015	Panel	P&S
Sarkodie and Adams (2018)	South Africa	1971-2017	Time series	P&S
Mukhtarov et al. (2022)	Azerbaijan	1996-2019	Time series	N&IS
Acheampong et al. (2021)	45 SSA countries	1960-2017	Panel	P&S
Vatamanu and Zugravu (2023)	27 EU member countries	2000-2020	Panel	P&S
Mehrara et al. (2015)	ECO countries	1992-2011	Panel	P&S
Wang et al. (2022).	32 OECD countries	1997-2019	Panel	P&S
Saadaoui and Chtourou (2022).	Tunisia	1984–2017	Time series	P&S
Hadj et al. (2023)	14 ME and CIS nations	1984-2017	Panel	P&S
Ndubuisi et al. (2023)	46 SSA countries	2010-2020	Panel	N&S
Islam et al. (2022)	Bangladesh	1990-2019	Time series	P&S
Rahman and Sultana (2022)	19 emerging countries (include Poland)	2002-2019	Panel	P&S

Note: N&S= Negative and statistically significant; P&S= Positive and statistically significant; N&IS= Negative and statistically insignificant; CIS= The Commonwealth of Independent States; ECO=Economic Cooperation Organization; EU= European Union; OECD= the Organization for Economic Cooperation and Development; SSA=Sub-Saharan African Countries.

3. MODEL SPECIFICATION AND DATA

3.1. Model Specification

This article investigates the relationship between institutional quality and renewable energy consumption. For 19 emerging countries (including Poland), Rahman and Sultana (2022) suggested a framework in which renewable energy consumption is a function of institutional quality proxied by control of corruption, government effectiveness, exports, GDP per capita, and gross fixed capital formation. In addition, Saadaoui and Chtourou (2022) used functional specification for Tunisia, which analyzes the impact of institutional quality, financial development, and gross domestic product per capita on renewable energy consumption. Wang et al. (2022) have used institutional quality, GDP per capita, economic globalization, and political risk to explain renewable energy consumption in their empirical estimation.

Numerous prior studies have utilized a framework to examine the renewable energy consumption impacts of institutional quality alongside GDP and CO2 emissions. For example, Mukhtarov et al. (2022a) used a model specification to investigate the effect of institutional quality, GDP, and CO2 emissions on renewable energy consumption in Azerbaijan. Furthermore, Uzar (2020b) suggested a model specification to evaluate the impact of institutional quality on renewable energy consumption alongside income inequality, GDP, CO2 emissions, and trade openness.

Given the studies mentioned above, data availability, and the unique characteristics of country, the functional specifications presented in this article can be outlined as follows:

$$lnREN_t = \beta_0 + \beta_1 lnIQ_t + \beta_2 lnY_t + \beta_2 lnCO_{2,t} + \beta_2 lnTO_t + \varepsilon_t \quad (1)$$

where, RENt is real renewable energy consumption, IQt is institutional quality proxied by corruption perception index, Yt is real GDP per capita as proxy od income, CO2t is Carbon Dioxide emissions per capita, TOt is trade openness and εt is an error term.

3.2. Data

This study utilizes annual time series data for Poland from 1996 to 2021 for empirical estimation. The data period is determined by the availability of data. All variables are used in logarithmic form.

Renewable energy consumption (REN). This refers to the utilization of energy derived from renewable sources, presented as renewable energy use per capita in megawatt-hours. The data for this variable was collected from Our World in Data (Our World in Data, 2023).

Institutional quality (IQ). This is proxied by the corruption perception index (CPI). The Corruption Perceptions Index is a measurement that assigns scores to countries based on the perceived level of government corruption within each country. These scores span from zero to 100, where zero signifies higher corruption levels and 100 signifies lower corruption levels. It was obtained from Transparency International (2023).

Income (Y). It was measured by GDP per capita (US dollars at 2015 prices). It was gathered from the world development indicator (World Bank, 2023a).

Carbon Dioxide (CO2). CO2 emissions are provided in million tons of carbon per year, in per capita terms, and was gathered from the Global Carbon Atlas (2023).

Trade Openness (TO). This is the total trade as a percentage of GDP. It is computed as the sum of exports and imports, with both variables represented as proportions of the GDP. These data are sourced from the World Development Indicators database, WDI (2023a).

4. ECONOMETRIC METHODOLOGY

Before estimating the long-run relationship, the variables need to be tested for non-stationarity. The Augmented Dickey Fuller (ADF) test developed by Dickey and Fuller (1981) is utilized for this exercise. After stating the integration of the variables in the same order, as a next step, the variables will be tested for a long-run co-movement -cointegration relationship. The Engle-Granger test (1987) and Phillips-Ouliaris (1990) are used for testing the cointegration relationship. The long-run effect of independent variables on renewable energy consumption is estimated using the Canonical Cointegrating Regression (CCR- Park, 1992) method.

It is commonly recognized that the above-mentioned estimation methods are extensively utilized in time-series applications, and therefore, a comprehensive explanation of these techniques is omitted in this context. The detailed information for the ADF, Engle-Granger, and Phillips-Ouliaris tests has been provided by Dickey and Fuller (1981), Engle-Granger (1987), and Phillips and Ouliaris (1990), respectively.

Similarly, the CCR method is well documented by Park (1992) and offers a detailed resource for this approach.

5. EMPIRICAL RESULTS AND DISCUSSION

As outlined in the methodology section, our initial step involved examining the variables for characteristics of non-stationarity. The outcomes of this unit root analysis are presented in Table 2.

Table 2

Unit root tests results

	Variables	The ADF test		
		Level	First difference	
	REN	-0.0007	-8.9965***	
	IQ	-1.8156	-5.1081***	
	Y	-1.2974	-4.8511***	
	CO2	-0.7782	-3.6220***	
	TO	-1.6720	-5.8671***	

Notes: ***, represents rejection of the null hypotheses at the 1% significance levels;

As indicated in Table 2, all the variables exhibit integration of the first order, meaning they are non-stationary at their level form but stationary at their first differenced form. Thus, we can move forward to the subsequent stage, which involves assessing the long-term co-movement of these variables. The outcomes of the cointegration tests are provided in Table 3.

Table 3

Cointegration tests' results

Engle-Granger test		Phillips-Ouliaris test	
Test statistic	p-values	Test statistic	p-values
-7.286*	0.000	-7.341*	0.000
-33.235**	0.001	-33.930**	0.000

Notes: *Tau-statistic of Engle-Granger and Phillips-Ouliaris, **Z-statistic of Engle-Granger and Phillips-Ouliaris; No cointegration is the null hypothesis for both tests.

The Engle-Granger and Phillips-Ouliaris tests demonstrated cointegration with a significance level of 5%, as indicated in Table 3. Therefore, we can infer that the variables possess a cointegration relationship.

As a next step, we estimated the long-run impact of institutional quality, income, CO2 emissions, and trade openness on renewable energy consumption. For this purpose, the Canonical Cointegrating Regression (CCR) method was applied, and the findings are given in Table 4.

Table 4

Long-run estimation results

		Variables				
		IQ	**Y**	**CO2**	**TO**	**C**
coefficients		1.02	3.33	1.79	-0.59	-39.518
t-Statistics		3.0241	3.3533	1.8117	-0.5739	-5.0580
p-values		0.006	0.003	0.085	0.572	0.000

Note: Dependent variable=REN, C is constant.

The estimation results revealed that corruption has a positive and significant effect on renewable energy consumption. A 1.02% rise in renewable energy consumption is associated with a 1% rise in the corruption perception index. A higher institutional quality, measured by the corruption perception index may lead to stricter energy and environmental regulations, thereby resulting in a greater proportion of renewable energy sources. To put it differently, an increase in renewable energy consumption is tied to a reduction in corruption. When corrupt officials prioritize their own interests, they might disregard the environmental consequences of approved projects. The control of corruption reflects a strong institutional framework and serves as a barrier against the weakening of environmental regulations. Robust institutions make it more likely for decisions that prioritize environmental well-being to be made, thereby providing motivation for the adoption of renewable energy sources. Additionally, corruption acts as a barrier that inhibits long-term productive investments. Thus, efforts to control corruption can foster greater economic investment. In this situation, investors have the opportunity to raise their investments in renewable energy during a period when corruption acts as a deterrent and political uncertainty diminishes. The average value of control of corruption in Poland between 1996 and2021 stood at 0.55 points, with the lowest being 0.11 points in 2004 and the highest at 0.79 points in 1998. The most recent value was 0.57 points in 2021. By way of comparison, the global average for 2021 across 192 countries is -0.03 points. Here, it seems that Poland is far above the world average and ranks 55th out of 192 countries in 2021 (The GlobalEconomy, 2023). It is clear from these data that during the research period, Poland has made significant progress in the fight against corruption and achieved significant political and economic stability. This, in turn, resulted in the implementation of important economic projects, especially renewable energy projects. Based on the recent available World Bank data for Poland, the proportion of renewable energy in overall energy consumption has consistently risen in recent years, reaching 16.4% in 2020 (World Bank, 2023b). This result aligns with previous studies by Uzar (2020a), Uzar (2020b), Saadaoui and Chtourou (2022), Rahman and Sultana (2022), and Wang et al. (2022), which found the positive effects of different institutional indicators on renewable energy consumption.

In addition, we found that income measured by real GDP per capita is positively associated with renewable energy consumption in Poland. The positive impact of GDP on the utilization of renewable energy validates the notion that economic expansion and growing incomes have stimulated energy consumption, thereby fostering the enhancement of renewable energy resources. As Poland's economy has undergone growth, its energy consumption has also risen. Over the period 1990-2022, the GDP of Poland increased by 10.4 times, from 65.98 billion dollars in 1990 to 688.18 billion dollars in 2022 (World Bank, 2023c). The expansion of GDP has enabled Poland to allocate resources towards the development of both renewable energy technology and infrastructure, consequently contributing to an upsurge in the adoption of renewable energy sources. To illustrate, Poland has made substantial investments in wind power, leading to wind energy's emergence as the primary renewable energy source in the nation (Makrygiorgou and Alexandridis, 2017). Moreover, our findings are in alignment with research outputs from various studies by Sadorsky (2009) for G7 countries, Apergis and Payne (2014) in the case Central, Omri and Nguyen (2014) for high and middle-income countries, Nguyen and Kakinaka (2019) for High-income countries (include Poland), Mukhtarov et al. (2020) examining the Azerbaijani context, Karacan et al. (2021) investigating Russian cases, Mukhtarov et al. (2021) analyzing Kazakhstan, Rahman and, Sultana (2022) for 19 emerging countries (include Poland), and Mukhtarov et al. (2022b) for Turkey, Wang et al. (2022) for 32 OECD countries, and Mukhtarov and Mikayilov (2023) for Poland, all of which identify a significant and positive relationship.

It was revealed that a rise in CO2 emissions is positively related to REN in the long run. The positive effect of CO2 emissions can be interpreted that high levels of CO2 emissions may increase public awareness of the negative effects of fossil fuels on the environment and climate. This raised awareness can result in increased policy support and public demand for renewable energy sources. To reduce the environmental impact, governments, businesses, and individuals may become more inclined to invest in and adopt renewable energy technologies. Also, the positive impact of CO2 emissions was revealed by several studies, such as Omri and Nguyen (2014), Apergis and Payne (2014), Omri et al. (2015), Uzar (2020), and inter alia. Based on the estimation results, the impact of trade openness was not statistically significant. Our findings are in alignment with research outputs from some studies, like Omri and Nguyen (2014) for high-income countries, Omri et al. (2015) for 64 countries, Brini et al. (2017) for Tunisia, and Uzar (2020) for 43 developed and developing (including Poland) economies, which found an insignificant effect of trade openness.

5. CONCLUSION

Given the significance of adopting renewable energy, this research investigates the impact of institutional quality, income, CO2 emissions, and trade openness on renewable energy consumption in Poland. Following the assessment of variables for a unit root, it was determined that they exhibited stationarity in the first differenced order. Consequently, these variables could be assessed for a shared long-term pattern. The Engle-Granger and Phillips-Ouliaris cointegration tests were utilized to examine the cointegration association among the variables. The outcomes affirm the presence of a cointegrating relationship among the variables. The CCR technique was utilized to evaluate the impact of independent variables on REN in the long run. The outcomes of CCR indicated a positive and statistically significant impact of institutional quality, income, and CO2 emissions on the utilization of renewable energy. On the contrary, the impact of trade openness on renewable energy consumption was revealed to be insignificant.

The policy implications stemming from this research are outlined below: (a) Offer more incentive programs such as grants, tax credits, and subsidies to attract domestic and foreign investors to renewable energy projects in Poland. Such incentives can assist in offsetting initial costs and boosting adoption. (b) Improve and revise legislation pertaining to renewable energy projects, with a focus on enhancing clarity and maintaining uniformity. This includes the optimization of permission procedures, the establishment of unambiguous technical criteria, and the provision of project development guidelines. (c) It is essential to maintain transparent and accountable decision-making procedures pertaining to policies concerning renewable energy. This has the potential to cultivate trust and instill confidence among many parties. (d) Engage in active participation in efforts and agreements of the European Union that involve climate change and renewable energy. Collaboration may lead to the sharing of best practices, finance, and technology. (e) Modernize the energy infrastructure in order to support a bigger capacity of renewable energy sources. It involves smart grid technologies that allow for more effective integration of renewable sources and demand response systems.

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